

Ceramics Recapture Cutting Tools Market

U.S. DEPARTMENT
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OFFICE OF
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TECHNOLOGIES



Transportation FOR THE 21ST CENTURY

Background

The use of high temperature materials can enable greater operating efficiencies of heat engines, thereby leading to increased vehicular fuel economy. In the 1980s, The U.S. Department of Energy's Energy Conversion and Utilization Technologies (ECUT) Program conducted technology base research to toughen brittle ceramic materials. One method to toughen ceramics is to combine them with other materials to form composites. Silicon carbide (SiC) whisker-reinforced alumina and tungsten carbide-nickel aluminide composite ceramics were successfully developed by the Oak Ridge National Laboratory (ORNL) and were later determined to be ideally suited for applications as metal cutting tools.

The Technology

Metal cutting tools (e.g., drill bits) are shaping instruments that form an object during the manufacturing process. ORNL's patented SiC whisker-reinforced alumina ceramics have led to more durable metal cutting tools by improving strength and fracture toughness without compromising the hardness of the matrix at high temperatures. This combination of materials has revolutionized the machining of high-temperature nickel alloys used in the jet-engine industry. SiC whisker-reinforced alumina has increased machining rates by up to 800 percent and has dramatically decreased the frequency of cutting tool replacement. In one case, switching to SiC whisker-reinforced cutting tools reduced a 5-hour nickel alloy (Inconel) machining operation to only 20 minutes. Tungsten carbide chemically bonded with a modified nickel aluminide alloy also offers several advantages over

other commercial materials. Cutting tools made of tungsten carbide-nickel aluminide are harder and may last longer than conventionally used cobalt-bonded tungsten carbide cutting tools. This new ceramic-metal composite is also less expensive and utilizes non strategic metals that are more readily available.

Commercialization

Worldwide sales of SiC whisker-reinforced alumina ceramic products now exceed \$30 million per year. This material is used for machine tool inserts (e.g., cutting tips and drills) for machining metals and wood products, as well as for tooling in metal-forming operations (e.g., beverage and food can stamping dies). Advanced Composite Materials Corporation, Cercom, Dow Chemical Company, GTE, Hertel Cutting Technology, Kennametal, Kermont Corporation, and Valenite Corporation all hold licenses for this ORNL-patented ceramic. The rapid growth of several smaller U.S. companies in this market is due principally to the widespread use of these whisker-reinforced materials in their products. Tungsten carbide-nickel aluminide composite ceramics are used commercially throughout the world for rock- and coal-drilling equipment and dies. This material is patented by Martin Marietta Energy Systems, Inc., and Dow Chemical Company, Inc. SiC whisker-reinforced alumina and tungsten carbide-nickel aluminide composite ceramics have enabled the United States to recapture a substantial international market share of the cutting tools industry that was on the verge of disappearing in the late 1980s.

Benefits

- SiC cutting tools reduces machining times by up to 800 %
- SiC cutting tools sales by U.S. companies exceed \$30 million a year
- Ceramic cutting tools have created 300 new U.S. jobs



For more information on how DOE is helping America remain competitive in the 21st century, please contact:

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